TRANSGENIC PLANTS FOR HEAVY METAL PHYTOREMEDIATION

a bibliographic review

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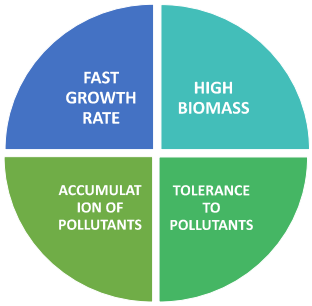
IDEAL PLANT FOR PHYTOREMEDIATION



How can we create an ideal plant for phytoremediation?

The ideal plant for phytoremdiation doesn't exist in nature, that's why the aim of transgenic phytoremediation is to create a plant model that combines all of these characteristics.

GENETIC ENGINEERING

Remediation genes

+

Target plants

Yeast and bacteria are the main donors of these genes because they have considerably developed these abilities (due to their extreme habitats). They are furthermore, the most studied organisms, genetically and functionally speaking. Also, mammals or even plants can be donors of this kind of genes. These remediation genes are involved in:

- ACCUMULATION of heavy metals
  - UPTAKE from soil to the roots
  - TRANSLOCATION from roots
- TOLERANCE to heavy metals
- VOLATILIZATION of heavy metals

The ideal candidates for heavy metal remediation should be plants with:

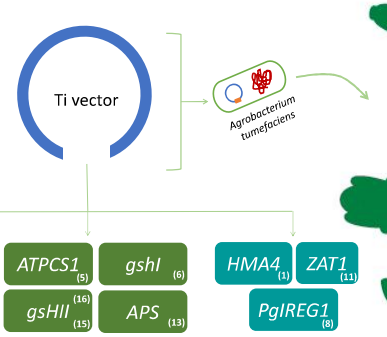
- HIGH BIOMASS
- FAST GROWTH
- HIGHLY STUDIED METABOLISM

Most of the studies have been carried out with *Brassica juncea, Arabidopsis thaliana* and *Nicotiana tabacum*

Brassica juncea — *Arabidopsis thaliana* — *Nicotiana tabacum*

TRANSGENIC PHYTOEXTRACTION

Phytoextraction is the removal of the pollutants from the soil by uptake and accumulation in the harvestable parts of the plant. Genetic engineering pretends to improve the conditions of phytoextraction by the transfer of hyperaccumulator/tolerance genes into ideal plant candidates. Transgenic phytoextraction has been studied in diverse assays, through the incorporation of heavy metal accumulation and tolerance genes into the plant genome by the infection of *Agrobacterium tumefaciens* :

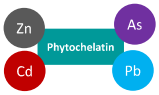


METALLOTHIONINES

Low molecular weight proteins, cysteine-rich capable of binding heavy metals through the thiol group of their cysteine residues, reducing their toxicity.

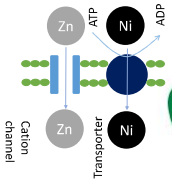
PHYTOCHELATINS

Posttranscriptional proteins, cysteine rich that chelate heavy metals decreasing their free concentration in the environment.



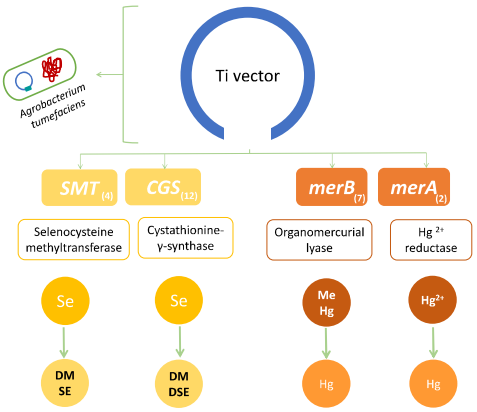
METAL TRANSPORTERS

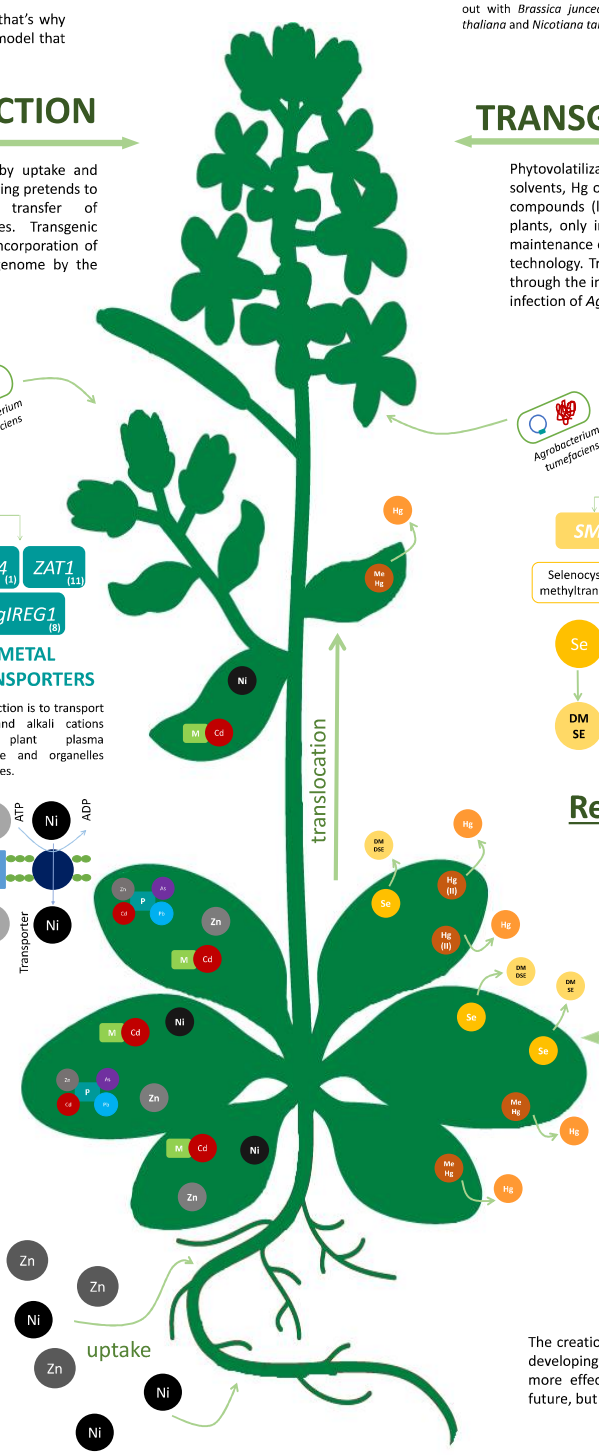
Their function is to transport metals and alkali cations across plant plasma membrane and organelles membranes.



TRANSGENIC PHYTOVOLATILIZATION

Phytovolatilization is a process where plants take up pollutants as chlorinated solvents, Hg or Se from soil and release them into the atmosphere as volatile compounds (less toxic) through transpiration. This process is not natural in plants, only in microorganisms; but plants have higher biomass and better maintenance conditions, that's why there's interest in the development of this technology. Transgenic phytovolatilization has been studied in diverse assays, through the incorporation of volatilization genes into the plant genome by the infection of *Agrobacterium tumefaciens:*





Results:

METALLOTHIONINES

- (+) TOLERANCE
- (−) UPTAKE
- (−) TRANSLOCATION
- (=) ACCUMULATION

PHYTOCHELATINS

- (+) TOLERANCE
- (−) UPTAKE
- (−) TRANSLOCATION
- (+) ACCUMULATION

METAL TRANSPORTERS

- (+) TOLERANCE
- (+) UPTAKE
- (+) TRANSLOCATION
- (+) ACCUMULATION

Results:

- (+) TOLERANCE
- (+) VOLATILIZATION

Hg — 200x less toxic than MeHg or Hg (II)

DM DSE, DM SE — less toxic than Se

FUTURE DIRECTIONS

Improvement of phytoremediation by genetic engineering is a fact, but to make it an efficient remediation technology for the future there's a need of:

The creation of specific models for each case will be possible in the future, by developing a specialized plant model for each pollutant, making the removal more effective. This technology can open the door to a more sustainable future, but first it has to be explored further from the molecular basis.

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